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President

BELLCOMM, INC.,

Washington, D. C.

QUARTERLY PROGRESS REPORT

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ABSTRACT

The activities of Bellcomm, Inc., during the quarter ending December 31, 1962, are summarized. Reference is made to reports issued during this period covering individual technical studies.

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Table of Contents

GENERAL SYSTEMS ENGINEERING ACTIVITIES

Significant activities of a continuing nature and activities which are preliminary to definition of task order studies are included in the following summary of general systems engineering efforts:

A. Available computer simulation programs are being adapted for application to studies of the LOR mission. For this purpose the mission has been divided into phases as follows:
   1. Powered flight from launch to translunar injection.
   2. Ballistic flight from translunar injection to lunar orbit insertion.
   3. Lunar parking orbit.
   4. LEM descent.
   5. LEM ascent.
   6. Moon to earth ballistic flight.
   7. Reentry.

   These phases will be simulated by two basic programs: a powered flight simulation and a ballistic flight simulation. During the quarter, the powered flight simulation program was demonstrated in terms of C-5 powered flight through the end of second stage burn. Work on adapting these programs will continue until a capability for simulating all phases of the LOR mission has been demonstrated.

B. Development of a new computer program specifically designed for efficient simulation of the entire LOR mission was initiated for the purpose of deriving reference trajectories and conducting system studies.

C. A catalogue of guidance sensitivity coefficients is being calculated for use in studies of guidance and navigation techniques. During the quarter, approximate sensitivities were calculated analytically for portions of the trajectory in close proximity to the moon. Specifically, sensitivities were calculated for near lunar approach trajectories, quasi-circular lunar parking orbits, and equiperiod and Hohmann lunar descent trajectories. Additional effort is being directed toward more accurate determination of sensitivities through use of computer programs which include all important perturbing effects.

D. A special computer program is being developed to evaluate the effects of variations in stage parameters on the capability and reliability of the composite launch vehicle. The program will be able to handle variations in design data, mating, propellant loading, and certain types of substandard performance.

E. Compilation of data required for a spacecraft performance study was begun. This study will use a velocity increment computer program to allow spacecraft propulsion system parameters and module weight changes to be evaluated for their effects on the performance of the mission.

F. The possible use of the LEM propulsion system to provide additional abort modes has been reviewed to identify problems which would require study if this proposal is pursued. (1)

G. Possible back-up modes of operation for the lunar launch to lunar rendezvous phase were identified and costs in terms of fuel were estimated.

H. A family of charts is being prepared to present interrelated space program schedules for use in future studies of test programs, data gathering programs, etc. A chart for the various vehicle systems associated with the Apollo program has been prepared using data extracted from NASA program control schedules. Similar charts for Gemini and OSS space probes are in process of preparation.

I. During the quarter, Bellcomm personnel participated in the work of the LEM Task Group. This activity consisted of attending the group meetings (seven) and providing technical ideas and concepts for discussion. In addition, seven Work Statements defining suggested studies of immediate importance to the LEM design were prepared.

J. Preparations were made for the first meeting of the Apollo reference trajectory working group scheduled for January 3, 1963. An agenda for the meeting was prepared and sample lists defining the data needed for Apollo reference trajectory calculations were compiled. These lists cover system configuration, system constraint, and preliminary input data requirements.

K. A report(2) was issued covering a review of the Ranger program to explore its ability to furnish information helpful to the development of Project Apollo. Recommendations were suggested to increase the probability that useful and timely data will be derived. This document covered effort of the preceding quarter which was continued under Task Order No. 4 during the current quarter.

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1. A Novel Use of the LEM Propulsion System, T. M. Burford, October 31, 1962.
2. Ranger Support of Project Apollo (Draft), B. T. Howard and D. B. James, September 17, 1962.

TASK ORDER NO. 1

ASSIST NASA IN THE PREPARATION OF DOCUMENTS DEFINING THE APOLLO MISSION AND SPECIFYING SYSTEM CHARACTERISTICS. Estimated completion date - September 30, 1963.

Phase I of this task was completed in the preceding quarter with the issuance on August 24, 1962, of a Bellcomm report entitled, "Project Apollo Preliminary System Specification." Work during the current quarter under Phase II of the task was directed toward the preparation of a more complete system specification to be issued by the Office of Systems, OMSF.

During the quarter, numerous trips were made by members of the Bellcomm staff to NASA development centers and to the offices of NASA contractors to gather information needed for preparation of a more complete specification. Preliminary drafts were discussed with representatives of the Office of Systems to define better the degree of detail appropriate for the specification. On November 30, 1962, a draft of the specification document[3] was transmitted formally to the Office of Systems. This draft reflected information available and system decisions made, as of that date, and included those parts of the final document which Bellcomm recommended for inclusion in a first edition of the specification. It is estimated that the November 30 draft covers between one-half and two-thirds of the subject matter envisioned for the specification in its completed form.

During December, the November 30 draft was reviewed with representatives of the Office of Systems, and the incorporation of agreed-upon revisions was initiated. Effort to supply missing information and sections will continue during the first quarter of 1963.

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3. Apollo System Specification-Draft, November 30, 1962 (Confidential)

TASK ORDER NO. 2

CONDUCT A PRELIMINARY STUDY OF CHECKOUT AND LAUNCH FROM LUNAR SURFACE. Estimated Completion date - January 31, 1963

Negotiations are in process to expand the scope of work for Task Order No. 2 to cover development of an integrated checkout and maintenance plan for all phases of the Apollo mission. The activities described below were carried out under the broader guidelines of the proposed revision.

The fundamental checkout system requirements for the space vehicle and ground based network were formulated jointly by the Office of Systems and Bellcomm and will be included in the Apollo System Specification being prepared under Task Order No. 1. Among the items specified are:

1. Scope and purpose of checkout throughout the Apollo mission.
2. Compatibility requirements which must be met by the space vehicle and the ground system.
3. Ground rules pertaining to the use of common components for prelaunch and postlaunch checkout purposes.
4. Locations and the capabilities of the various facilities required to perform the checkout operations.
5. Times and locations in the Apollo mission profile at which major checkout operations will be performed.

Proposed space vehicle on-board checkout equipment is being evaluated for conformance with the above requirements.

TASK ORDER NO. 3

ESTIMATE THE COMPUTING NEEDS OF THE OFFICE OF SYSTEMS AND BELLCOMM, INC. Estimated completion date - October 31, 1962

This task was completed with the transmittal of a final report[4] to NASA-ME on November 30, 1962, covering the significant conclusions and recommendations resulting from the study.

The joint computing needs of the Office of Systems and Bellcomm were determined for the latter part of 1963 and projected to the 1965-66 time period. The volume and nature of computational requirements predicted by this study dictated use of a large scientific machine. The size was selected to insure adequate reserve capacity to avoid conversion problems brought on by early obsolescence, and to provide a good level of service to both organizations during periods of concurrent demands.

An IBM 7044 computer was recommended for installation at the Bellcomm office location, with remote input-output facilities at the Office of Systems. IBM 1401 equipment was recommended for off-line use. It was anticipated that the equipment could be delivered during the third and fourth quarters of 1963.

The study also presented an outline of the organization and functions of a Computer Operations Group.

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4. Estimation of Computer Needs, A. E. Speckhard, November 30, 1962.

TASK ORDER NO. 4

CARRY OUT A STUDY LEADING TO THE CLASSIFICATION AND CHARACTERIZATION OF THE NATURAL ENVIRONMENTAL HAZARDS TO APOLLO MISSION SUCCESS. Estimated completion date - January 31, 1963.

Under this task, a number of studies dealing with meteoroids, radiation, and the lunar surface were undertaken or continued during the report period.

A study[5] was made of the available data concerning the meteoroid environment with particular attention to the uncertainties in the analysis. Activities programmed for the future have been evaluated to determine their potential contribution to better understanding of the meteoroid hazard. Additional experiments were proposed.

Subsequent to the study covered in the preceding paragraph, consultation with a number of workers in the meteoroid field led to the conclusion that early models used for the meteoroid penetration hazard to the Apollo spacecraft were unduly conservative. A new model was generated which indicates that shielding requirements may be lowered.[6]

A study to estimate the dosage due to man-made radiation belts for the LOR and EOR modes was documented in a report dated October 5, 1962.[7] The effects of variations in some of the orbital parameters and of possible future changes in the radiation environment were considered.

Existing knowledge of solar flare proton radiation has been reviewed. At this time, only a limited number of flare-proton events have been

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5. The Meteoroid Hazard to Project Apollo, G. T. Orrok, October 8, 1962.
6. The Meteoroid Penetration Hazard, G. T. Orrok and B. T. Howard, November 2, 1962.
7. Radiation Environment of EOR and LOR, D. B. James and H. J. Schulte, October 5, 1962.

observed and only a very tentative probabilistic description of their occurrence is possible. A report dated October 30, 1962, [8] summarizes available information and explores the potential danger of such radiation to space missions. Work is continuing toward the generation of models of the radiation hazard offered by solar proton counts, galactic cosmic rays, and the high energy proton and electron belts surrounding the earth.

A model of the lunar surface for use in Project Apollo is in preparation. Consideration is being given to the types and extent of lunar surface data needed for carrying out the mission.

Space environment information required for the Apollo program has been summarized, and compared with the information-collecting capabilities of the unmanned program, and presented in a report dated October 30, 1962. [9]

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8. Hazards to Apollo From Solar Proton Radiation, H. J. Schulte, October 30, 1962.
9. Apollo and the Unmanned Program, W. S. Boyle, B. T. Howard and D. B. James, October 30, 1962.

TASK ORDER NO. 5

ASSIST NASA IN DEVELOPING A MISSION ASSURANCE PROGRAM FOR APOLLO. Estimated completion date - November 30, 1962.

A revision of this task order which includes extension of the estimated completion date is being negotiated.

A number of reliability and quality assurance programs representative of space industry practice were reviewed during the report period to develop a background for later presentations to OMSF on an appropriate mission assurance program for Apollo. This activity included visits to several installations for reviews with cognizant personnel. A report outlining a possible Mission Assurance Program for Apollo is being prepared.

A simple model showing normal and abort sequences for the Apollo mission was derived and a preliminary assessment of the apportionment problem was completed.

TASK ORDER NO. 6

FORMULATE THE SYSTEMS REQUIREMENTS AND DEVELOP A BROAD IMPLEMENTATION PLAN FOR THE COMMUNICATIONS AND TRACKING SYSTEM. Estimated completion date - (Phase II) September 30, 1963

Work on Phase I of Task Order No. 6, was completed as of December 15, 1962. Effort on Phase II of Task Order No. 6 will include special studies covering problem areas defined during the Phase I effort, and the generation of an operational information flow plan for Apollo.

Communications and Tracking System performance requirements were developed during the Phase I effort and will be reflected in the Ground Communications and Tracking System and Integrated Mission Control Center portions of the Apollo System Specification. A complete report on Phase I studies will be issued during January, 1963. The more significant conclusions resulting from this effort pertain to:

A. LAUNCH AZIMUTH

The azimuth of launch must be variable over a limited range in order to permit some flexibility in exact time of launch. A two-hour period during which launch can be initiated without incurring excessive penalty in required propulsion can be obtained using a launch azimuth angle between 72 and 90 degrees. This range of launch azimuth permits maximum use of existing ground stations for coverage of the first few parking orbits.

B. LOCATION OF INJECTION INTO LUNAR TRANSFER TRAJECTORY

Significant advantages can be obtained by injection of the spacecraft into lunar transfer trajectory from the earth parking orbit in the region between the Hawaiian Islands and the eastern coast of North America on the second, third, or fourth pass over this region. Such injection permits the following advantages:

(1) At least one complete orbit of the earth for in-flight checkout.

(2) Tracking and communications during and following the second burn of the S-IVB by existing land stations, which have good communication facilities to the IMCC, supplemented by one ship in the Pacific Ocean.

(3) Arrival at the moon during a time convenient for direct viewing of the lunar landing from the United States.

(4) Adequate opportunities for launch and injection.

These conditions can be met on four successive days of the lunar month using launch azimuths between 72 and 90 degrees and injecting on any of two or three orbits selected from the first four.

C. TRACKING SHIPS

At least two tracking ships will be required, one positioned in the Atlantic Ocean east of Bermuda to track the final portion of insertion into earth parking orbit, and the other in the Pacific Ocean about midway between the Hawaiian Islands and North America for coverage during injection of the spacecraft into lunar transfer trajectory. Additional ships may be needed for tracking during reentry.

D. RADARS FOR TRACKING DURING NEAR-EARTH PHASES

The tracking accuracy of the FPS-16 radars now installed at many Mercury sites is adequate to support the Apollo mission in its near-earth phase. A modification of the receiver range unit to extend its calibration to 10,000 miles is required at some sites to provide tracking during injection into the lunar transfer trajectory. Specifically, the FPS-16 radars now installed at the Woomera and Hawaii sites may be used unmodified; those at the Canaveral, Bermuda, and California sites should have the extended range capability. A standard FPS-16, or its equivalent, should be installed at Kana, and FPS-16's with extended range, or an equivalent such as the FPQ-6, should be installed at the Canary Islands, Guaymas, and Texas sites.

E. GROUND-TO-SPACECRAFT DATA LINK

A channel for digital transmission of command and advisory data from earth stations to the spacecraft should be provided. This conclusion is based primarily on the following considerations:

(1) Transmission of advisory or guidance data to the spacecraft is believed to be an important area of IMCC responsibility. Although this might be done by voice transmission, digital transmission can be made substantially more efficient and reliable.

(2) Such a digital channel is essential if the philosophy is adopted that the ground system should be able to return the spacecraft to earth in case the astronauts or essential equipments are disabled.

TASK ORDER NO. 7

REVIEW THE LUNAR LOGISTIC SYSTEM PROGRAM AND ITS RELATIONSHIP TO THE APOLLO PROGRAM. Estimated completion date - November 1, 1962.

Negotiations are in process to extend the scope of work under this task to include further studies of the data acquisition capabilities of various Lunar Logistic Systems. It is anticipated that the estimated completion date for the extended task will be changed to March 1, 1963.

Possible Lunar Logistic Systems are being studied actively by several groups both within NASA and in the aerospace industry. While the Bellcomm study drew upon these efforts for determination of potential Lunar Logistic Vehicle effectiveness, it focussed on an examination of the value of an LLS to the Apollo project. The concept for an LLS using an unmanned LEM was developed in the course of the Bellcomm study and was included in the systems evaluated.

Preliminary conclusions, reached as a result of studies during the report quarter, are that the most important functions of an LLS with respect to Apollo would be to implement a careful survey of the landing site prior to the first unmanned landing and to increase significantly the scope of scientific facilities available to the astronauts. A full report[10] covering the study has been transmitted to NASA-OMSF.

Effort under Task 7 has included delineation of an appropriate site survey payload meeting the 1500-pound weight limitation of a C-1B System. Further studies to determine the most effective way of enhancing early scientific capability through use of an LLS suggest a lunar surface laboratory for use by the Apollo astronauts. Detailed conclusions regarding the laboratory and the site survey payload will be covered in reports to be issued during the next quarter.

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10. Some Comments and Recommendations on a Lunar Logistic System, B. T. Howard and D. B. James, November 20, 1962.

ADMINISTRATIVE ITEMS OF INTEREST

Significant administrative events of the past quarter which have contributed to the growth of Bellcomm technical capability, or to the fulfillment of contract requirements, are noted below:

Personnel

As of January 3, 1963, the Bellcomm staff included 72 technical employees and 54 administrative employees, representing a total increase of 18 over the previous quarter. Although 80 per cent of the technical personnel have originated from Bell System affiliates, the majority of those added during the last quarter were new to the Bell System.

Office Facilities

Additional office space was occupied at 1001 Vermont Avenue, N. W., bringing to five the temporary locations now occupied in Washington, D. C.

Construction of more permanent office facilities leased by Bellcomm continued. Occupancy is expected to begin in the first quarter of 1963.

A central filing facility has been established to include administrative and technical correspondence and reports of general interest.

Contract and Financial

The definitive contract (NASw-417) covering Bellcomm operations became effective December 31, 1962, retroactive to March 28, 1962.

A subcontract with Space Technology Laboratories, Inc., for support in developing an Apollo reference trajectory was in negotiation toward the end of the quarter.

During November, the firm of Lybrand, Ross Bros., and Montgomery completed an audit of Bellcomm's system of internal accounting control. As a result of the audit, minor changes were made in our accounting procedures.


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